Traumatic Brain Injury in Massachusetts

Incidence and Prevention

Massachusetts Department of Public Health
Bureau of Family and Community Health
Injury Prevention and Control Program

1994

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TRAUMATIC BRAIN INJURY IN MASSACHUSETTS

Incidence and Prevention

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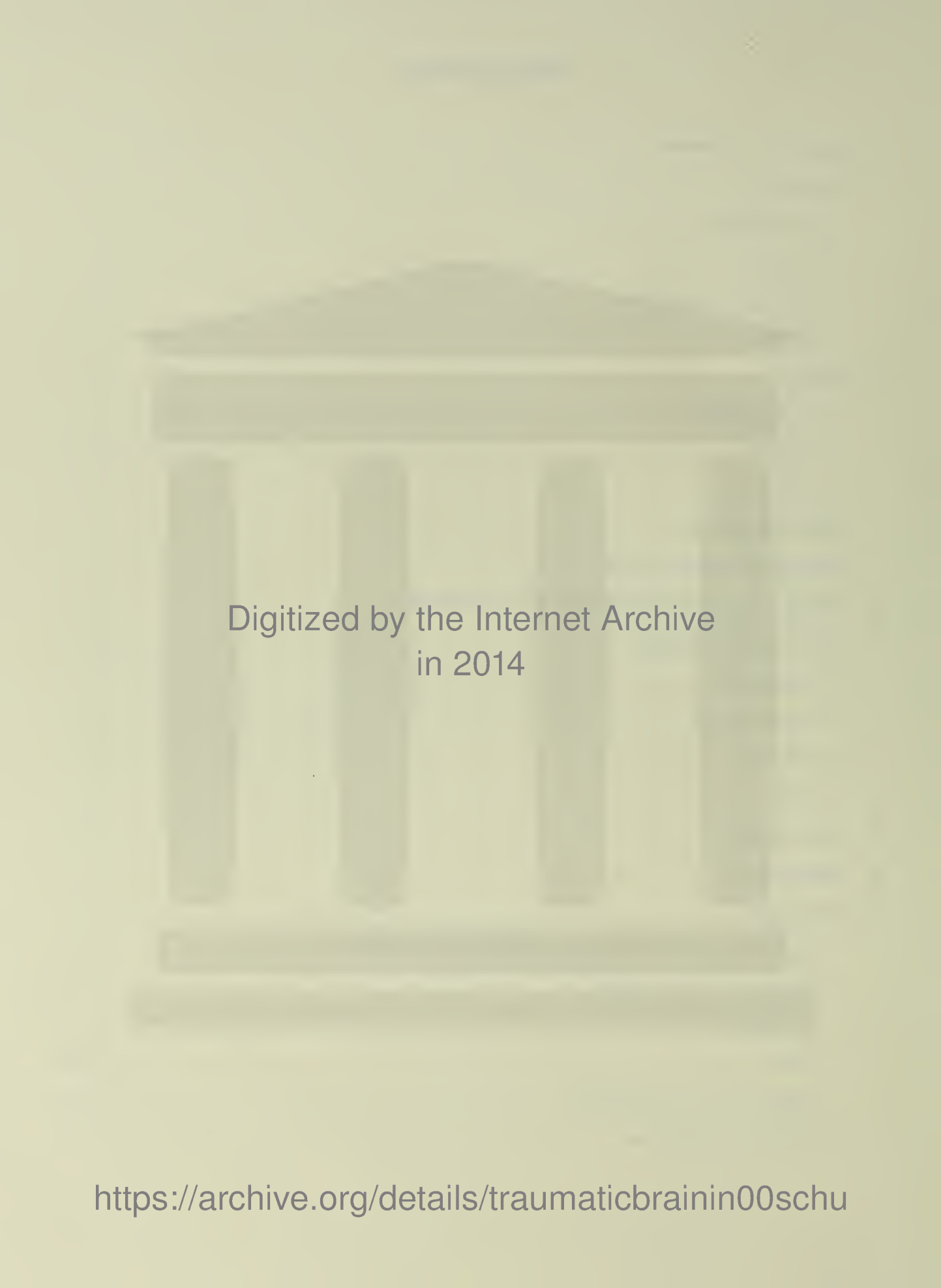

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Executive Summary

This report describes the frequency, causes, demographic, and clinical characteristics of new cases of traumatic brain injury (TBI) among Massachusetts residents; these include fatal cases and nonfatal cases that require hospital admission, as well as estimates of nonhospitalized cases requiring outpatient treatment from emergency departments. This is the first Massachusetts report to describe the frequency of TBI by cause and to estimate the lifetime cost of health care and lost earnings.

An estimated one of every 216 Massachusetts residents experiences a TBI serious enough to result in death or hospital-based treatment each year. In 1990, this was an estimated 28,000 people. For every person who dies from TBI, nine people survive to be discharged from acute care hospitals to home or to other health care facilities, and an estimated 38 people are treated and released from emergency departments.

Young people 15-24 years old have the highest hospitalization and estimated emergency department rates and the second highest fatality rate per 100,000 residents. Males have higher rates for all classes of injury. People 65 years old and older have the highest fatality rate and the second highest hospitalization rate. Children and young adults comprise an estimated 55% of TBI survivors.

Fatality rates per 100,000 residents are highest for motor vehicle crashes (3.1) and firearms (3.1) and lowest for falls (2.0). Nonfatal hospitalization rates are highest for motor vehicle crashes (34.6) and falls (30.2) and lowest for firearms (0.6). Estimated emergency department rates are highest for falls (113.2), followed by motor vehicle crashes (102.2).

The case fatality rate (*i.e.*, the percentage of fatalities among people who are hospitalized or who die without being hospitalized) is highest for TBI caused by firearms (84%), with far lower rates for motor vehicle crashes (8%) and falls (6%).

Intentional actions, interpersonal and self-inflicted, account for 37% of fatal TBI, 13% of hospitalized TBI, and an estimated 19% of emergency department visits. Suicide is responsible for the majority (74%) of fatal firearm-related TBIs with homicide accounting for almost all of the remainder (25%). A higher percentage of TBI-related suicides (97%) result from firearms than TBI-related homicides (60%).

The total estimated lifetime cost of health care and lost earnings for TBI in 1990 is almost $1 billion: $261 million for fatal TBI and $632 million for nonfatal hospitalized TBI; $153 million for lifetime health care and $740 million for lifetime lost earnings. Estimated emergency department-treated TBI increases the total estimated cost by as much as $19 million. These are conservative estimates based on available data that do not include the full spectrum of long-term costs of care.

Overview

"My experiences have led me to believe that primary prevention is the key. Traumatic brain injury has life-long implications for the survivor, family and community-at-large. It is a disability that is almost always preventable, but we must first recognize and acknowledge how substance abuse, child abuse and violence play a causal role in the incidence of TBI."

- Debra Kamen, Director of Statewide Head Injury Program, Massachusetts Rehabilitation Commission

The purpose of this report is to describe the frequency, causes, demographic, and clinical characteristics of new cases of TBI among Massachusetts residents including fatal cases and nonfatal cases that require hospital admission, as well as estimates of nonhospitalized cases requiring outpatient treatment from emergency departments. This is the first Massachusetts report to describe the frequency of TBI by cause and to estimate the lifetime cost of health care and lost earnings.

Traumatic brain injury (TBI) is associated with more injury-related deaths than injury to any other specific body region. TBI is caused by being hit in the head, being penetrated in the head, striking a stationary object, or being violently shaken. Those who survive TBI are often disabled by the injury, although the prevalence of such disability is unknown. More people are surviving severe TBI as a result of improvements in emergency medical services and acute care. Such individuals require a range of health, rehabilitation, education, social, and vocational services provided by families, governmental and nongovernmental agencies, and others. (See the Appendix of this report for a detailed list of cognitive and neurobehavioral consequences of TBI.)

In 1988, the Statewide Head Injury Program (SHIP) of the Massachusetts Rehabilitation Commission published a report on the incidence and lifetime service needs of TBI survivors.(9) Readers familiar with the SHIP report will be aware of differences in incidence from the current report. Fewer people who experience a TBI are hospitalized than previously, a reflection of the trend toward reducing time in inpatient care and treating people in the least restrictive environment.

The U.S. Interagency Head Injury Task Force has stated that "a fundamental shift in the approach to the problem of head injury is imperative. It must be grounded in a commitment to primary prevention... In order to make informed decisions about prevention, it is necessary to identify the high-risk populations, what types of TBI are sustained, and when, where, and under what circumstances is TBI likely to occur. Epidemiologic research of TBI is essential, as well as development of methods to assess the effectiveness of prevention."(4) Nationally, motor vehicle crashes, falls, violence (interpersonal and self-inflicted), and sports and recreation are the predominant causes of TBI with variations in rates by age, sex, race, and socioeconomic status.

Methodology

Fatal TBI cases are based on the Massachusetts Department of Public Health's Registry of Vital Records and Statistics mortality file, averaged for 1989-91. Nonfatal TBI cases that require hospitalization are calculated based on the Massachusetts Rate Setting Commission's Uniform Hospital Discharge Data Set, averaged for 1989-91. Estimates of Massachusetts emergency department visits for nonhospitalized TBI are calculated based on a 1988 Pennsylvania study (13) because statewide data for Massachusetts are not available. In light of the overall trend toward reducing inpatient care, we believe it is important to include an estimate of emergency department visits despite some demographic and other differences between Massachusetts and Pennsylvania. (See the Appendix of this report, especially Table A-3.)

This report describes cases for which TBI was the principal or an associated diagnosis. TBI includes concussions, skull fractures, and intracranial injuries. See the Appendix of this report for a detailed outline of the methodology for calculating the frequency of the three classes of injury (fatal, nonfatal hospitalized, and nonhospitalized emergency department) and the estimated lifetime cost of health care and lost earnings.

Frequency

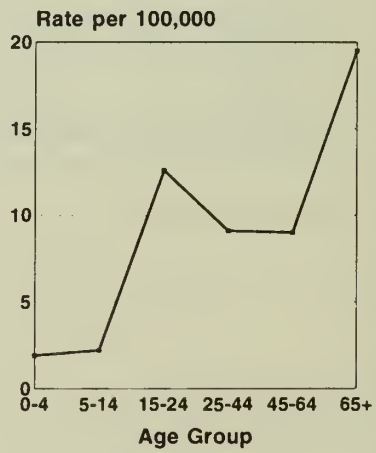
- An estimated one of every 216 Massachusetts residents experiences a TBI serious enough to result in death or hospital-based treatment (inpatient or emergency department) each year. In 1990, this was an estimated 28,000 people.
- One of every four persons who dies from an injury is diagnosed with a TBI. The percentage is highest for children 5-14 years old (29%) and lowest for children 0-4 years old (17%).
- One of every nine persons hospitalized with a principal diagnosis of injury is diagnosed with a principal or associated diagnosis of TBI. The percentage decreases with increasing age (24% for 0-4, 7% for 65+).
- For every person who dies from TBI, nine people survive to be discharged from acute care hospitals to home or to other health care facilities, and an estimated 38 people are treated and released from emergency departments. Others are treated in HMOs, physicians' offices, outpatient clinics, and other medical facilities.
- Among people who receive hospital-based treatment for TBI, 2% (586) die, 19% (5,192) are admitted, and an estimated 79% (22,038) are treated and released from emergency departments. It is important to note that an unknown proportion of the latter group will require some degree of further care in an ambulatory care setting or at home.

Demographic Patterns (See Table 1.)

Fatalities

- People 65 years old and older experience the highest fatality rate per 100,000 residents (twice the overall rate), followed by people 15-24 years old. Children 0-14 years old have the lowest rate. (See Figure 1.)
- The fatality rate for males is three times the rate for females.

Figure 1
Fatality Rates

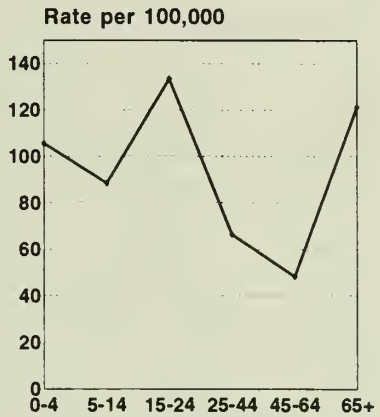


- Males and females 65 years and older have the highest rates for their respective genders
- The overall age-adjusted fatality rate for black residents is 16.2 per 100,000 residents compared to 8.2 for white residents and 9.1 for Hispanic residents. Black residents 15-24 years old have a rate almost three times the white rate for the same age group. Research, however, has shown that when socioeconomic status is taken into account, most differences among racial and ethnic groups are reduced.(6) (See Table 2.)

Hospitalizations

- Residents 15-24 years old, especially 15-19 year olds, experience the highest TBI-related hospitalization rate per 100,000 residents (50% higher than the overall rate), followed by people 65 years old and older. People 45-64 years old have the lowest rate. (See Figure 2.)
- When the rate for infants is calculated separately, they are shown to have the highest rate among children and youth 0-24 (183.0 per 100,000).
- The hospitalization rate for males is almost twice the rate for females. Males 15-24 years old have the highest rate among males (1.7 times the overall male rate).
- Females 65 years old and older have the highest rate among females (almost twice the overall female rate).

Figure 2
Hospitalization Rates



Estimated Emergency Department Visits

- People 15-24 years old have the highest estimated emergency department rate per 100,000 residents (almost twice the overall rate), followed by children 0-14 years old. People 65 years old and older have the lowest estimated rate. (See Figure 3.)
- The elderly are the only age group with an estimated emergency department rate lower than their hospitalization rate.
- The estimated emergency department rate for males is almost 40% higher than the female rate.

Figure 3
Estimated Emergency Department Rates

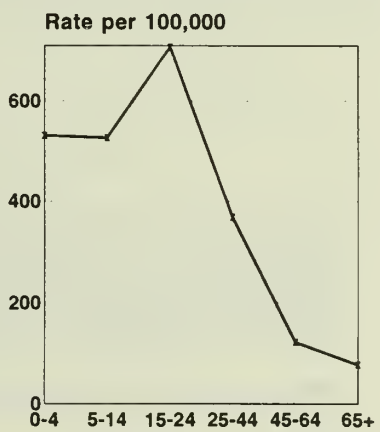


Table 1

Traumatic Brain Injury in Massachusetts, 1990

Rates by Age/Sex Group and Class of Injury

Age/Sex Group	Census	Total		Fatal		Hospitalized		Estimated ED	
		N	Rate	N	Rate	N	Rate	N	Rate
All	**6,016,425**	**27,816**	**462.3**	**586**	**9.7**	**5,192**	**86.3**	**22,038**	**366.3**
0-4	421,349	2,689	638.2	8	1.9	445	105.6	2,236	530.7
5-14	723,635	4,464	616.9	16	2.2	640	88.4	3,808	526.2
15-24	933,224	7,965	853.5	118	12.6	1,246	133.5	6,601	707.3
25-44	2,013,198	8,936	443.9	184	9.1	1,337	66.4	7,415	368.3
45-64	1,110,014	1,987	179.0	100	9.0	536	48.3	1,351	121.7
65+	815,005	1,774	217.7	159	19.5	988	121.2	627	76.9
Male	**2,888,745**	**16,052**	**555.7**	**433**	**15.0**	**3,290**	**113.9**	**12,329**	**426.8**
0-4	215,445	1,466	680.5	5	2.3	245	113.7	1,216	564.6
5-14	371,381	2,838	764.2	10	2.7	449	120.9	2,379	640.6
15-24	465,946	4,372	938.3	95	20.4	898	192.7	3,379	725.1
25-44	994,597	5,520	555.0	148	14.9	961	96.6	4,411	443.5
45-64	531,001	1,242	233.9	79	14.9	338	63.7	825	155.3
65+	310,375	613	197.5	95	30.6	399	128.6	119	38.5
Female	**3,127,680**	**11,764**	**376.1**	**153**	**4.9**	**1,902**	**60.8**	**9,709**	**310.4**
0-4	205,904	1,223	594.0	3	1.5	200	97.1	1,020	495.5
5-14	352,254	1,626	461.6	6	1.7	191	54.2	1,429	405.7
15-24	467,278	3,593	768.9	23	4.9	348	74.5	3,222	689.5
25-44	1,018,601	3,416	335.4	36	3.5	376	36.9	3,004	294.9
45-64	579,013	745	128.7	21	3.6	198	34.2	526	90.9
65+	504,630	1,161	230.1	64	12.7	589	116.7	508	100.6

Note: Rates per 100,000 residents are annualized for 1989-91.

Source: Massachusetts Department of Public Health, Registry of Vital Records and Statistics; Massachusetts Rate Setting Commission, Uniform Hospital Discharge Data Set.

Table 2

Traumatic Brain Injury in Massachusetts, 1990

Fatality Rates by Age and Racial/Ethnic Group

Age Group	All			White			Black			Hispanic		
	N	Rate	Adj. Rate	N	Rate	Adj. Rate	N	Rate	Adj. Rate	N	Rate	Adj. Rate
All	**586**	**9.7**	**8.7**	**1509**	**9.5**	**8.2**	**141**	**17**	**16**	**77**	**8.9**	**9.1**
0-4	8	1.9		15	1.5		4	4.7		4	3.7	
5-14	16	2.2		33	1.8		6	4.5		8	4.7	
15-24	118	12.6		281	11.9		50	31.6		16	8.8	
25-44	184	9.1		445	8.4		52	18.2		39	13.8	
45-64	100	9.0		274	8.9		14	11.7		7	8.0	
65+	159	19.5		461	19.7		12	22.6		3	9.7	

Note: Age unknown for 3 black people.

Note: Overall rates per 100,000 residents by race are annualized for 1989-91 and age-adjusted by the direct method using the 1940 U.S. Census data.

Causes

- Motor vehicle crashes, firearms, and falls, regardless of intent, account for 84% of fatal TBI, 76% of nonfatal hospitalized TBI, and an estimated 59% of emergency department visits for TBI. Other causes of TBI, mainly nonfirearm assaults and being struck by an object (*e.g.*, in sports), account for 16% of fatal TBI, 24% of nonfatal hospitalized TBI, and an estimated 41% of emergency department visits for TBI. (See Table 3.)
- Motor vehicle crashes are the leading cause of fatal TBI (almost equivalent to firearms) and nonfatal hospitalized TBI, accounting for 32% and 40% respectively.
- Firearms are the second leading cause of fatal TBI (almost equivalent to motor vehicles), accounting for 31%, and the least frequent cause of nonfatal hospitalized TBI (less than 1%).
- Falls are the third leading cause of fatal TBI (21%) and the second leading cause of nonfatal hospitalized TBI (35%).
- Fatality rates per 100,000 residents are highest for motor vehicle crashes (3.1) and firearms (3.1) and lowest for falls (2.0). Nonfatal hospitalization rates are highest for motor vehicle crashes (34.6) and falls (30.2) and lowest for firearms (0.6). Estimated emergency department rates are highest for falls (113.2), followed by motor vehicle crashes (102.2).
- An estimated 26% of motor vehicle-related fatalities, 33% of fall-related fatalities, and 65% of firearm-related fatalities are associated with TBI.
- An estimated 23% of motor vehicle-related nonfatal hospitalizations, 11% of fall-related nonfatal hospitalizations, and 3% of firearm-related nonfatal hospitalizations are associated with TBI.
- An estimated 28% of emergency department visits for TBI are caused by motor vehicle crashes and an estimated 31% by falls. There are no firearm-related emergency department visits for TBI; all these injuries result in death or hospital admission.
- The case fatality rate (*i.e.*, the percentage of fatalities among people who are hospitalized or who die without being hospitalized) is highest for TBI caused by firearms (84%), with far lower rates for motor vehicle crashes (8%) and falls (6%).
- Violence, both interpersonal and self-inflicted, accounts for 37% of fatal TBI, 13% of hospitalized TBI, and an estimated 19% of emergency department visits.

Table 3

Traumatic Brain Injury in Massachusetts, 1990

Percent Distribution of Cause by Class of Injury

Cause	Total		Fatal		Hospitalized		Estimated ED	
	N	%	N	%	N	%	N	%
All causes	27,816	100%	586	100%	5,192	100%	22,038	100%
Unintentional:	22,278	80.1	359	61.3	4,499	86.7	17,420	79.0
MV occupant	7,306	26.3	105	17.9	1,405	27.1	5,796	26.3
MV/pedestrian	704	2.5	37	6.4	367	7.1	300	1.4
Motorcyclist	116	0.4	16	2.7	100	1.9	0	0.0
Bicyclist	918	3.3	9	1.5	318	6.1	591	2.7
Fall	8,204	29.5	116	19.9	1,761	33.9	6,327	28.7
Struck by object	4,376	15.7	5	0.9	301	5.8	4,070	18.5
Firearm	4	0.0	2	0.3	2	0.0	0	0.0
Other	523	1.9	34	5.8	205	4.0	284	1.3
Unspecified	127	0.5	35	5.9	40	0.8	52	0.2
Intentional:	5,078	18.3	215	36.5	664	12.7	4,199	18.4
Assault:	4,921	17.7	75	12.7	647	12.4	4,199	18.4
Firearm	55	0.2	46	7.7	9	0.2	0	0.0
Other	4,866	17.5	29	5.0	638	12.2	4,199	18.4
Self-inflicted:	157	0.6	140	23.8	17	0.3	0	0.0
Firearm	142	0.5	136	23.2	6	0.1	0	0.0
Other	15	0.1	4	0.7	11	0.2	0	0.0
Unknown intent:	460	1.7	12	2.1	29	0.6	419	1.9
Firearm	18	0.1	1	0.2	17	0.3	0	0.0
Other	442	1.6	11	1.9	12	0.2	419	1.9

Note: Percentages are based on data for 1989-91.

Source: Massachusetts Department of Public Health, Registry of Vital Records and Statistics; Massachusetts Rate Setting Commission, Uniform Hospital Discharge Data Set.

Causes

"The majority of our patients have been injured through incidents involving automobiles, bicycles, guns, and motorcycles as well as falls. Such injuries result in physical and cognitive impairments that will be with our patients for the rest of their lives. Unlike what is portrayed in the Soap Opera Coma, a person who has had a severe head injury does not simply wake up and carry on with their lives. For these individuals and their families, life will never be the same."

- Jackie Wolff, Director of Staff Education, Greenery Rehabilitation Center

Motor Vehicles (See Table 4 and Figures 4 and 5.)

- Among motor vehicle-related TBIs, 2% are fatal, 25% are hospitalized, and an estimated 73% are treated and released from emergency departments.
- Residents 15-44 years old, especially males, account for the majority of fatal (67%) and nonfatal hospitalized (63%) motor vehicle-related TBI.
- Among males and females, the highest rates of fatal and nonfatal hospitalized TBI per 100,000 residents are for those 15-24 years old. The males in this age group have a fatality rate three times the overall rate and a nonfatal hospitalization rate almost three times the overall rate.
- Motor vehicle crashes are the leading cause of fatal TBI for people under 25, and the second leading cause for people 25-64.
- Motor vehicle crashes are the leading cause of nonfatal hospitalized TBI for people between the ages of 5 and 64 and the second leading cause for people 65 years old and older.
- A higher percentage of TBI fatalities for white and Hispanic residents are caused by motor vehicle crashes than for black residents (33% and 27% vs 20%).
- Fatalities are distributed among motor vehicle occupants (57%), pedestrians (20%), motorcyclists (8%), bicyclists (3%), and other transport (12%).
- Nonfatal hospitalizations are distributed among motor vehicle occupants (69%), pedestrians (18%), motorcyclists (5%), bicyclists (5%), and other transport (3%).
- More than half (52%) of fatal TBI and almost a third (32%) of nonfatal hospitalized TBI among bicyclists are caused by motor vehicle crashes.

Table 4

Traumatic Brain Injury in Massachusetts, 1990

Motor Vehicles: Rates by Age/Sex Group and Class of Injury

Age/Sex Group	Total		Fatal		Hospitalized	
	N	Rate	N	Rate	N	Rate
All	**2,265**	**37.6**	**186**	**3.1**	**2,079**	**34.6**
0-4	69	16.4	4	0.9	65	15.4
5-14	236	32.6	12	1.7	224	31.0
15-24	787	84.3	64	6.9	723	77.5
25-44	654	32.5	60	3.0	594	29.5
45-64	229	20.6	21	1.9	208	18.7
65+	290	35.6	25	3.1	265	32.5
Male	**1,369**	**47.4**	**128**	**4.4**	**1,241**	**43.0**
0-4	38	17.6	3	1.4	35	16.2
5-14	152	40.9	7	1.9	145	39.0
15-24	511	109.7	47	10.1	464	99.6
25-44	415	41.7	43	4.3	372	37.4
45-64	122	23.0	15	2.8	107	20.2
65+	131	42.2	13	4.2	118	38.0
Female	**896**	**28.6**	**58**	**1.9**	**838**	**26.8**
0-4	31	15.1	1	0.5	30	14.6
5-14	84	23.8	5	1.4	79	22.4
15-24	276	59.1	17	3.6	259	55.4
25-44	239	23.5	17	1.7	222	21.8
45-64	107	18.5	6	1.0	101	17.4
65+	159	31.5	12	2.4	147	29.1

Note: Rates per 100,000 residents are annualized for 1989-91.

Source: Massachusetts Department of Public Health, Registry of Vital Records and Statistics; Massachusetts Rate Setting Commission, Uniform Hospital Discharge Data Set.

Figure 4
Motor Vehicle Fatality Rates

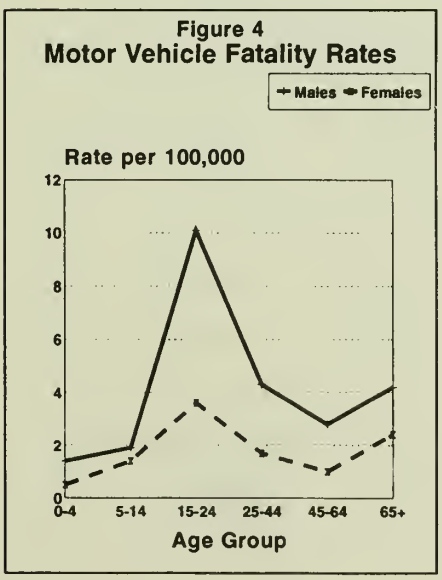
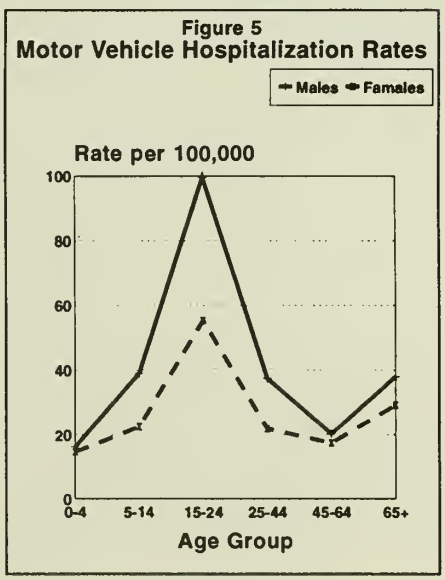


Figure 5
Motor Vehicle Hospitalization Rates



Firearms (See Table 5 and Figures 6 and 7.)

- Among firearm-related TBIs, 84% are fatal, 16% are hospitalized, and none are treated and released from emergency departments.
- Males account for 86% of fatalities and 77% of nonfatal hospitalizations.
- Suicide is responsible for the majority (74%) of fatal firearm-related TBIs with homicide accounting for almost all of the remainder (25%). A higher percentage of TBI-related suicides (97%) result from firearms than TBI-related homicides (60%).
- Assaults are responsible for 27% of firearm-related hospitalized TBI, suicide attempts for 18%. Half were recorded as unknown intent, while two were unintentional.
- Adults 25-44 account for 40% of fatalities, followed by 15-24 year olds (22%). Residents 15-24 account for 65% of nonfatal hospitalizations, followed by 25-44 year olds (29%).
- Residents 15-24, especially males, have the highest firearm-related fatality rate per 100,000 residents, followed by males 65 years old and older (primarily suicide).
- For nonfatal hospitalizations, males and females 15-24 years old have the highest rates.
- Regardless of intent, firearms are the leading cause of fatal TBI for people 25-64 and the second leading cause for those 15-24.
- A much higher percentage of TBI fatalities for black (51%) and Hispanic (43%)residents are caused by firearms than for white residents (29%).
- Firearm-related hospitalizations have the lowest rate of discharge to home with no further care (67% vs 86% overall) and the highest percentage with length of stay greater than 28 days (23% vs 5% overall). The total number of nonfatal hospitalized cases is very low.
- Suicide is the leading cause of fatal TBI (24%) from all TBI causes, almost all from firearms and three times the number of firearm-related homicides.
- The rate of firearm-related suicide among male TBI cases increases steadily with age from 0.2 per 100,000 residents 5-14 years old to 7.2 per 100,000 residents 65 years old and older.
- The rate of firearm-related homicide among male TBI cases is highest among 15-24 year olds and decreases steadily with increasing age.

Table 5

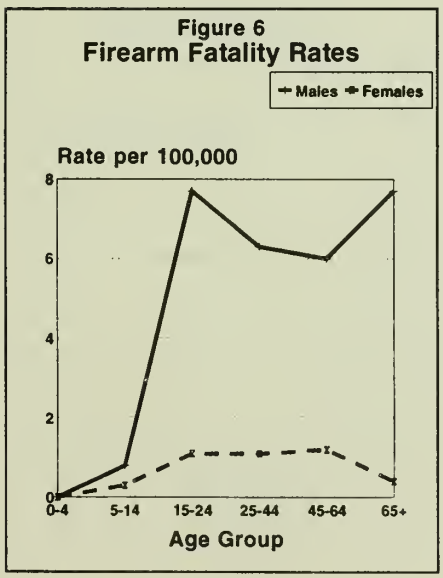
Traumatic Brain Injury in Massachusetts, 1990

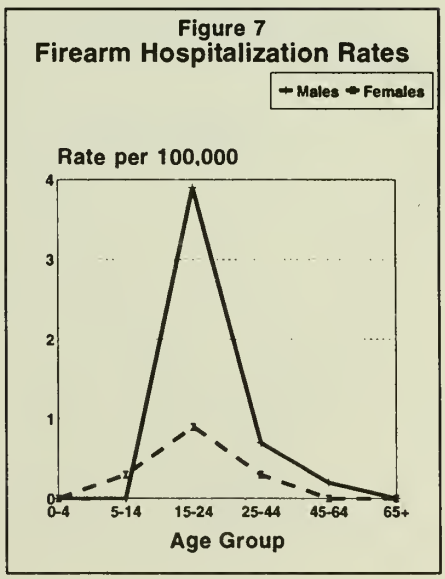
Firearms: Rates by Age/Sex Group and Class of Injury

Age/Sex Group	Total		Fatal		Hospitalized	
	N	Rate	N	Rate	N	Rate
All	**218**	**3.6**	**184**	**3.1**	**34**	**0.6**
0-4	**0**	**0.0**	**0**	**0.0**	**0**	**0.0**
5-14	5	0.7	4	0.6	1	0.1
15-24	**63**	**6.8**	**41**	**4.4**	**22**	**2.4**
25-44	84	4.2	74	3.7	10	0.5
45-64	**40**	**3.6**	**39**	**3.5**	**1**	**0.1**
65+	26	3.2	26	3.2	0	0.0
Male	**184**	**6.4**	**158**	**5.5**	**26**	**0.9**
0-4	**0**	**0.0**	**0**	**0.0**	**0**	**0.0**
5-14	3	0.8	3	0.8	0	0.0
15-24	**54**	**11.6**	**36**	**7.7**	**18**	**3.9**
25-44	70	7.0	63	6.3	7	0.7
45-64	**33**	**6.2**	**32**	**6.0**	**1**	**0.2**
65+	24	7.7	24	7.7	0	0.0
Female	**34**	**1.1**	**26**	**0.8**	**8**	**0.3**
0-4	**0**	**0.0**	**0**	**0.0**	**0**	**0.0**
5-14	2	0.6	1	0.3	1	0.3
15-24	**9**	**1.9**	**5**	**1.1**	**4**	**0.9**
25-44	14	1.4	11	1.1	3	0.3
45-64	**7**	**1.2**	**7**	**1.2**	**0**	**0.0**
65+	2	0.4	2	0.4	0	0.0

Note: Rates per 100,000 residents are annualized for 1989-91.

Source: Massachusetts Department of Public Health, Registry of Vital Records and Statistics; Massachusetts Rate Setting Commission, Uniform Hospital Discharge Data Set.





Falls (See Table 6 and Figures 8 and 9.)

- Among fall-related TBIs, 1% are fatal, 21% are hospitalized, and an estimated 78% are treated and released from emergency departments.
- Males constitute almost two-thirds (64%) of fall-related fatal TBIs and more than half (56%) of fall-related nonfatal hospitalized TBI cases.
- People 65 years old and older constitute almost two-thirds (64%) of fall-related fatal TBI and more than a third (36%) of fall-related hospitalized TBI cases.
- Among both males and females, the highest fatality rates per 100,000 residents are for those 65 years old and older.
- Both males and females 0-4 years old and 65 years old and older have the highest hospitalization rates.
- Falls are the leading cause of fatal TBI for people 65 years old and older, and the second leading cause for people 45-64 (tied with motor vehicles).
- Falls are the leading cause of nonfatal hospitalized TBI for children 0-14 and adults 45 years old and older.
- A higher percentage of TBI fatalities for white residents (22%) are caused by falls than for black (14%) and Hispanic residents (10%).
- The case fatality rate for falls increases with age.
- Most falls are unintentional for all classes of injury, with emergency department visits having the highest percentage of intentional falls (8%).
- A third of fatal falls were on or from stairs or steps, 5% were from buildings or windows, 4% were to another level, 4% were on the same level, 4% were from ladders or scaffolding, 2% were from chairs or beds, and half were coded as other or unspecified.
- A fifth of fall-related hospitalizations were falls on or from stairs or steps, 14% were to another level, 11% were on the same level, 6% were from buildings or windows, 5% were from chairs or beds, 3% were from ladders or scaffolding, 3% were from playground equipment, 1% were sports-related, and more than a third were coded as other or unspecified.

Table 6

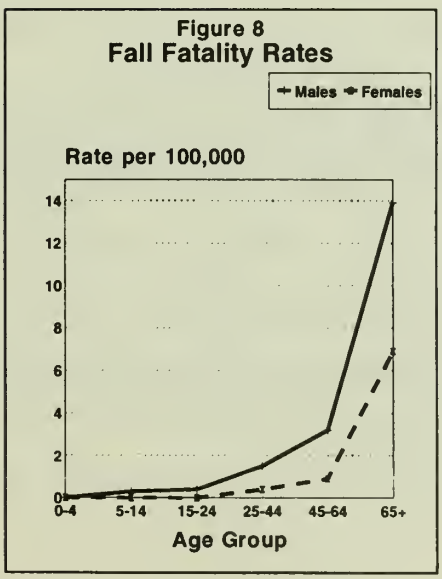
Traumatic Brain Injury in Massachusetts, 1990

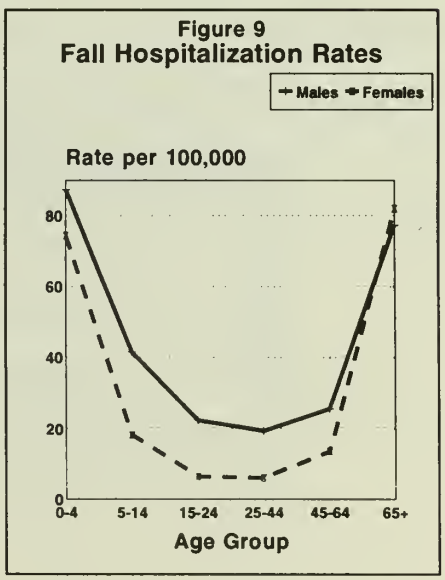
Falls: Rates by Age/Sex Group and Class of Injury

Age/Sex Group	Total		Fatal		Hospitalized	
	N	Rate	N	Rate	N	Rate
All	**1,936**	**32.2**	**122**	**2.0**	**1,814**	**30.2**
0-4	341	80.9	0	0.0	341	80.9
5-14	219	30.3	1	0.1	218	30.1
15-24	136	14.6	2	0.2	134	14.4
25-44	272	13.5	19	0.9	253	12.6
45-64	236	21.3	22	2.0	214	19.3
65+	732	89.8	78	9.6	654	80.2
Male	**1,092**	**37.8**	**78**	**2.7**	**1,014**	**35.1**
0-4	188	87.3	0	0.0	188	87.3
5-14	155	41.7	1	0.3	154	41.5
15-24	106	22.7	2	0.4	104	22.3
25-44	207	20.8	15	1.5	192	19.3
45-64	153	28.8	17	3.2	136	25.6
65+	283	91.2	43	13.9	240	77.3
Female	**844**	**27.0**	**44**	**1.4**	**800**	**25.6**
0-4	153	74.3	0	0.0	153	74.3
5-14	64	18.2	0	0.0	64	18.2
15-24	30	6.4	0	0.0	30	6.4
25-44	65	6.4	4	0.4	61	6.0
45-64	83	14.3	5	0.9	78	13.5
65+	449	89.0	35	6.9	414	82.0

Note: Rates per 100,000 persons are annualized for 1989-91.

Source: Massachusetts Department of Public Health, Registry of Vital Records and Statistics; Massachusetts Rate Setting Commission, Uniform Hospital Discharge Data Set.





Clinical Patterns

- The overall case fatality rate (*i.e.*, the percentage of fatalities among people who are hospitalized or who die without being hospitalized) is 10% and ranges from a low of 2% for children 0-14 years old to a high of 12% for people over 44 years old.
- The percentage of hospitalized patients discharged home with no further care (as listed on the discharge record) steadily decreases with age. Patients older than 64 years of age have the highest percentage of transfers to other acute care hospitals, skilled nursing facilities, and intermediate care facilities, as well as continued home care. It is important to note that the disposition of "home with no further care" recorded on discharge records may not reflect the extent of subsequent care either at home or in another setting (See Table 7.)

Table 7

Traumatic Brain Injury in Massachusetts, 1990

Hospitalizations: Percent Distribution of Disposition by Age Group

Age Group	All	Home	Transfer	SNF	ICF	Home Care	LAA	Chronic/ Rehab.	Psych.	Other
All	100%	**80.7**	**2.8**	**2.6**	**1.3**	**4.6**	**1.8**	**4.4**	**0.3**	**1.5**
0-4	100%	96.2	1.3	0.0	0.1	1.3	0.2	0.5	0.0	0.4
5-14	100%	94.8	1.4	0.2	0.0	1.7	0.1	1.4	0.0	0.4
15-24	100%	87.4	2.6	0.5	0.1	2.0	1.5	4.6	0.2	1.2
25-44	100%	83.7	2.6	0.4	0.2	2.5	3.8	4.8	0.4	1.4
45-64	100%	78.9	3.5	1.4	0.7	4.6	2.7	6.2	0.4	1.6
65+	100%	53.3	4.7	11.4	6.0	14.2	0.6	6.1	0.4	3.3

SNF: Skilled nursing facility. ICF: Intermediate care facility. LAA: Left against medical advice.

Note: Percentages are based on data for FY 1989-91.

Source: Massachusetts Rate Setting Commission, Uniform Hospital Discharge Data Set.

Table 8

Traumatic Brain Injury in Massachusetts, 1990
Hospitalizations: Percent Distribution of Length of Stay by Age Group

Age Group	Median Days	1-7 Days	8-14 Days	15+ Days
All	3	75.8	12.1	12.1
0-4	1	94.1	3.5	2.5
5-14	1	91.9	4.3	3.8
15-24	2	81.6	9.7	8.7
25-44	3	75.3	12.3	12.4
45-64	4	66.6	15.2	18.2
65+	6	55.6	21.9	22.5

Note: Percentages are based on data for FY 1989-91.

Source: Massachusetts Rate Setting Commission, Uniform Hospital Discharge Data Set.

- The percentage of patients discharged from acute care hospitals within one week decreases with age. The median length of stay increases with age; half of children 0-14 are discharged in one day; half of people 65 years old and older are discharged within 6 days. It is important to note that length of stay for acute care is not necessarily indicative of level of severity or extent of subsequent care. (See Table 8.)
- Injured people are categorized in the following clinical groups:
  1. **TBI only**: 67% of TBI fatalities; 34% of TBI hospitalizations.
  2. **Multiple injuries with TBI as principal diagnosis**: 17% of TBI fatalities; 43% of TBI hospitalizations.
  3. **Multiple injuries with TBI as associated diagnosis**: 6% of TBI fatalities; 16% of TBI hospitalizations.
  4. **Medical condition as principal diagnosis with TBI as associated diagnosis**: 10% of TBI fatalities; 6% of TBI hospitalizations.
- The median age for group 4 is much higher than for the other clinical groups: 75 years old for fatalities compared to 35-39 years old for other groups; 62 years old for hospitalizations compared to 21-28 years old for other groups. (See Table 9.)
- The percentage of patients discharged home with no further care (as listed on the discharge record) decreases from group 1 to group 4 (84%, 81%, 79%, 67%).

Table 9

Traumatic Brain Injury in Massachusetts, 1990

Percent Distribution of Clinical Groups by Age Group and Class of Injury

Age	Fatal:					Hospitalized:				
Group	All	1	2	3	4	All	1	2	3	4
All	**100%**	**67.2**	**17.3**	**5.9**	**9.7**	**100%**	**34.3**	**43.2**	**16.4**	**6.2**
0-4	100%	87.5	8.3	0.0	4.2	100%	70.7	22.4	3.5	3.5
5-14	100%	67.4	24.5	2.0	6.1	100%	51.9	35.2	10.7	2.2
15-24	100%	70.5	21.0	6.3	2.3	100%	26.2	50.3	21.5	2.0
25-44	100%	72.4	19.7	5.6	2.4	100%	24.1	50.1	20.9	5.0
45-64	100%	66.4	17.8	7.1	8.7	100%	31.1	42.6	17.7	8.6
65+	100%	58.3	10.9	5.9	25.0	100%	32.1	39.6	12.6	15.7
Median Age		39	35	38	75		21	28	28	62

Group 1: TBI only. Group 2: TBI and other injuries.

Group 3: Other injuries and TBI. Group 4: Medical condition and TBI.

Note: Percentages are based on data for 1989-91.

Source: Massachusetts Department of Public Health, Registry of Vital Records and Statistics; Massachusetts Rate Setting Commission, Uniform Hospital Discharge Data Set.

Estimated Lifetime Cost

Nationally, TBI costs almost $50 billion in estimated health care and lost earnings over the lifetime of people injured in one year who die or are discharged from acute care hospitals.(7) This estimate is conservative; it is based on available data that do not include the full spectrum of costs for health care and rehabilitation. According to 1990 guidelines from the American Re-Insurance Company for projecting insurance reserve estimates (1):

- A person with a severe TBI accrues $435,950 in first-year medical costs and $32,250-$63,050 in annual medical costs over his/her lifetime.
- A person with a moderate TBI accrues $179,600 in first-year medical costs and $6,700-$23,340 in annual medical costs over his/her lifetime.
- A person with a mild TBI accrues $500-$15,800 in first-year medical costs and $1,000-$2,500 in annual medical costs over his/her lifetime.
- A person in a persistent vegetative state accrues $149,200 in first-year medical costs and $185,100 in annual medical costs over his/her lifetime, and will live 3-30 years.
- A person in a deep persistent coma accrues $43,900-$208,000 in medical costs, and will die within 12 weeks.

Computation

Estimates of cost for Massachusetts residents are based on estimated national costs per injured person for 1985 (10) inflated to 1990 dollars and adjusted for higher costs in Massachusetts. Since more people are surviving TBI, the lifetime cost of health care continues to grow and the lifetime cost of lost earnings may decrease. The estimates of lifetime costs are conservative because they are derived from documented care, not care under a system that meets ideal standards of care. See the Appendix of this report for a detailed outline of the methodology for estimating the cost of TBI.

- The estimated lifetime cost of health care is the value in 1990 dollars of lifetime medical and nonmedical expenditures for goods and services related to an injury.
- The estimated lifetime cost of lost earnings is the market value in 1990 dollars of goods and services not produced over a lifetime because of injury-related short-term or long-term illness or disability, or premature death.

Estimated Cost

- The total estimated lifetime cost of health care and lost earnings for fatal and nonfatal hospitalized TBI in 1990 is almost $1 billion: $261 million for fatal TBI and $632 million for nonfatal hospitalized TBI; $153 million for lifetime health care and $740 million for lifetime lost earnings. (See Table 10.)
- Males 25-44 years old account for the highest lifetime cost, $290 million, followed by males 15-24 years old who account for $218 million in lifetime cost. Females 25-44 years old account for the highest cost among females, $74 million, followed by females 15-24 years old who account for $64 million.
- The estimated average per person cost of lifetime health care ranges from $2,000 to $30,000 for fatal TBI depending on age and sex; for nonfatal hospitalized TBI the range is $10,000 to $43,000.

Table 10

Traumatic Brain Injury in Massachusetts, 1990

Estimated Lifetime Cost by Age/Sex Group and Class of Injury

Age/Sex Group	Total Cost	FATAL N	Health Care CPP*	Health Care Total	Lost Earnings CPP*	Lost Earnings Total	Total Cost	HOSP. N	Health Care CPP*	Health Care Total	Lost Earnings CPP*	Lost Earnings Total	Total Cost
Total	$893,192,753	586		$10,419,193		$250,946,210	$261,365,403	5,192		$142,972,994		$488,854,356	$631,827,350
Males	667,723,686	433		8,648,845		205,757,740	214,406,585	3,290		104,143,766		349,173,335	453,317,101
0-4	19,059,635	5	12,995	64,975	309,152	1,545,760	1,610,735	245	16,362	4,008,690	54,858	13,440,210	17,448,900
5-14	50,808,085	10	19,005	190,050	452,145	4,521,450	4,711,500	449	23,586	10,590,114	79,079	35,506,471	46,096,585
15-24	217,834,772	95	28,336	2,691,920	674,124	64,041,780	66,733,700	898	38,656	34,713,088	129,608	116,387,984	151,101,072
25-44	290,727,124	148	30,142	4,461,016	717,085	106,128,580	110,589,596	961	43,064	41,384,504	144,384	138,753,024	180,137,528
45-64	63,472,069	79	13,834	1,092,886	329,117	26,000,243	27,093,129	338	24,727	8,357,726	82,903	28,021,214	36,378,940
65+	25,640,956	95	1,481	140,695	35,223	3,346,185	3,486,880	399	12,756	5,089,644	42,768	17,064,432	22,154,076
Unknown	181,045	1	7,303	7,303	173,742	173,742	181,045						
Females	225,469,067	153		1,770,348		45,188,470	46,958,818	1,902		38,829,228		139,681,021	178,510,249
0-4	13,779,091	3	10,846	32,538	276,851	830,553	863,091	200	14,047	2,809,400	50,533	10,106,600	12,916,000
5-14	20,260,946	6	15,719	94,314	401,242	2,407,452	2,501,766	191	20,225	3,862,975	72,755	13,896,205	17,759,180
15-24	64,474,193	23	22,526	518,098	574,985	13,224,655	13,742,753	348	31,710	11,035,080	114,070	39,696,360	50,731,440
25-44	74,103,356	36	21,529	775,044	549,546	19,783,656	20,558,700	376	30,976	11,646,976	111,430	41,897,680	53,544,656
45-64	22,408,020	21	10,442	219,282	266,530	5,597,130	5,816,412	198	18,227	3,608,946	65,569	12,982,662	16,591,608
65+	30,443,461	64	2,048	131,072	52,266	3,345,024	3,476,096	589	9,959	5,865,851	35,826	21,101,514	26,967,365

* CPP: Cost per person.

- The estimated average per person cost of lifetime lost earnings ranges from $35,000 to $717,000 for fatal TBI depending on age and sex; for nonfatal hospitalized TBI the range is $36,000 to $144,000.
- Emergency department-treated TBI increases the total estimated lifetime cost of TBI, possibly by as much as $19 million. (See Appendix.)
- Source of payment for initial hospitalization varies by age. The elderly (65+) primarily are covered by Medicare (81%); children 0-14 primarily are covered by commercial insurance, Blue Cross, or HMOs (63%), but almost a quarter are covered through Medicaid; more than half (56%) of residents 15-24 have private coverage, but a quarter are self-pay; adults 25-44 have the highest percentage of self-pay (29%) and less than half (45%) have private coverage; adults 45-64 primarily have private insurance (56%). It is important to note that initial source of payment is not necessarily indicative of source of payment for subsequent care. (See Table 11.)

Table 11

Traumatic Brain Injury in Massachusetts, 1990

Hospitalizations: Expected Source of Payment by Age Group

Age Group	All	Self-Pay	Free	Workers' Comp.	Medicare	Medicaid	Other Gov.	BC/CI/ HMO*	Other
All	100%	**17.6**	**2.1**	**3.0**	**16.9**	**9.9**	**0.5**	**46.5**	**3.5**
0-14	100%	10.0	0.4	0.2	0.1	23.9	0.6	63.0	1.7
15-24	100%	24.4	2.4	2.7	0.3	8.1	0.5	56.3	5.3
25-44	100%	29.0	4.6	6.1	2.2	8.1	0.6	44.9	4.5
45-64	100%	15.6	2.3	5.9	8.1	7.3	0.8	56.4	3.7
65+	100%	2.8	0.1	0.8	80.9	0.6	0.1	12.9	1.7

* Blue Cross, commercial insurance, health maintenance organization.

Note: Percentages are based on data for FY 1989-91.

Source: Massachusetts Rate Setting Commission, Uniform Hospital Discharge Data Set.

TBI Cases from One Emergency Department

"Even for head injury patients who are discharged from the emergency department, the cost of the ED visit may be only one tenth of their final health care costs, given patients' needs for follow-up MRIs, neurological work-ups, and other services."

-Director of Emergency Medicine, Massachusetts acute care hospital

The emergency department of one acute care hospital in Massachusetts has been using a logbook software package for recording all visits since 1991. The software was developed by the Weapon-Related Injury Surveillance System, a project funded by the U.S. Centers for Disease Control and Prevention to develop a surveillance system for gunshot wounds and stabbings. The major objective of the software is to meet the management and patient information needs of the emergency department. A secondary objective is to capture basic information for injury-related visits and to improve compliance with gunshot and stabbing reporting. The majority of emergency departments in Massachusetts are still using manual systems.

The hospital primarily serves a small city and surrounding towns. Another hospital that serves the area started using the software in 1993. The Community Health Network Area (CHNA) served by the hospital includes 170,000 people. Higher percentages of the population live below the poverty level, are AFDC recipients, are SSI recipients, or are unemployed than statewide. A higher percentage of residents are Hispanic than statewide (19% vs 5%) and lower percentages fall into the other racial and ethnic groups.(8) The TBI fatality rate per 100,000 residents for the CHNA is similar to the statewide rate. The TBI hospitalization rate is higher than the statewide rate which may reflect demographic differences and/or hospital admission policies. (See Table 12.)

Although a description of one hospital's emergency department visits associated with TBI is not representative of the state, it demonstrates the potential for surveillance of TBI from a user-friendly computerized system. In the future, a population-based description with data from the two hospital emergency departments that serve the CHNA will be available.

- During a one-year period (July 1, 1991 to June 30, 1992), 275 people were treated and released from the emergency department with a principal diagnosis of concussion, closed head injury, or skull fracture. Another 59 people were admitted to the hospital or transferred to other acute care hospitals. Two people left against medical advice. Forty-four percent of the fracture patients were treated and released compared to 87% of the patients with concussions or closed head injuries.
- Among cases that were released, more males than females were seen (57% vs 43%), 38% were children age 14 and under, and almost half (47%) were between 15 and 44 years old. People 65 years old and older represented the smallest age group (5%).
- The most common cause of injury was falls (44%), followed by motor vehicle crashes (28%), assaults (9%), struck by object (9%), and sports (5%). Seven of the injuries were work-related.

Table 12

Traumatic Brain Injury in Massachusetts, 1990 Age-Adjusted Rates by CHNA		
Community Health Network Area	**Fatal Rate**	**Hosp. Rate**
Statewide	**8.7**	**85.7**
1. Pittsfield	12.2	158.8
2. Greenfield	12.7	77.9
3. Holyoke/Chicopee/Northampton	6.5	72.7
4. Springfield	9.9	65.0
5. Southbridge	10.4	101.0
6. Milford	6.9	81.4
7. Framingham/Marlborough	4.4	77.2
8. Worcester	7.5	80.7
9. Fitchburg/Gardner	6.4	77.5
10. Lowell	9.8	68.4
11. Lawrence	8.9	108.2
12. Haverhill	8.3	73.6
13. Beverly/Gloucester	8.4	82.9
14. Lynn/Salem	11.3	87.2
15. Woburn	8.3	61.7
16. Medford/Malden	10.0	64.1
17. Cambridge/Somerville	5.9	58.1
18. Newton/Waltham	5.6	62.0
19. Boston	11.9	108.5
20. Quincy	7.3	90.0
21. Attleboro	8.5	58.1
22. Brockton	11.8	117.3
23. Plymouth	8.6	83.4
24. Taunton	10.3	106.0
25. Fall River	10.5	86.4
26. New Bedford	7.9	83.1
27. Cape/Islands	10.6	76.8

Note: Rates are annualized for 1989-91 and age-adjusted by the direct method using the 1940 U.S. Census data.

Note: Because of miscoded zip codes, hospital discharges for the following hospitals could not be assigned to CHNAs: Franklin Medical Center, New England Medical Center, St. John's Hospital.

Source: Massachusetts Department of Public Health, Registry of Vital Records and Statistics; Massachusetts Rate Setting Commission, Uniform Hospital Discharge Data Set.

- Falls were the leading cause for children 0-14 (70%), adults 45-64 (56%), and adults 65 years old and older (77%).
- Motor vehicle crashes were the leading cause for youth 15-24 (34%) and adults 25-44 (48%).
- Most of the assault-related injuries were experienced by males 15-44 years old.
- Our sample included a smaller percentage of people between 15 and 44 years old than the Pennsylvania sample (47% vs 61%) and a higher percentage of young children 0-4 years old (19% vs 10%) in spite of the fact that the two populations have similar age distributions.
- Our sample included a higher percentage of fall-related visits (44% vs 29%) and smaller percentages of assault (9% vs 18%) and sports-related (5% vs 13%) visits than the Pennsylvania sample.

Prevention Strategies

"Injury prevention should become part of the initial education of all children who attend schools so that issues such as bike helmets, seat belts, and prevention of interpersonal violence can be included in the educational curriculum of our schools."

- Robert Vinci, M.D., Director of Pediatric Emergency Department, Boston City Hospital

Injuries have long been considered to be the result of chance events or "accidents". However, injuries do not occur at random. The data presented in this report demonstrate the existence of predictable patterns of injuries that make it possible to differentiate which populations are at the highest risk for specific injury causes. When specific injury causes are identified and understood, prevention strategies can be designed that have the best chances of success.

The interaction of certain agents, hosts, and environmental factors are likely to lead to predictable injury risks. "Agents" comprise energy that actually causes the harm by damaging body tissue. For example, flames produce thermal energy that damages skin tissues, blood vessels, and other biological structures. The "host" (or individual at risk) can be described by age and gender, developmental level, physical impairment, and contributing factors such as blood alcohol concentrations. The "environment" includes the physical and psychosocial context in which an injury occurs. When the elements of agent, host, and environment combine in particular patterns and sequences, injuries are likely to occur. By dispelling the misperception that "accidental" injuries occur randomly, strategies can be implemented to prevent predictable events.

A range of proven strategies already exist for preventing and controlling traumatic brain injury (TBI). Some strategies are specific to prevention of TBI (*e.g.*, motorcycle and bicycle helmets), and many potentially can prevent related types of injuries, including TBI as well (*e.g.*, safety belts, violence prevention, reduction of alcohol consumption during high-risk activities). The human and financial costs of TBI are so high that primary prevention should have the highest priority. Once a TBI has occurred, reducing mortality, secondary complications, and disability, preserving the quality of life, and restoring as much functioning as possible should be the goals.

There is a variety of strategies that are effective for preventing intentional or unintentional injuries. The following is the ten-step model of countermeasures developed by William Haddon, a pioneer in injury control, to organize the different strategies in a logical framework. (2,3,5)

Primary Prevention (pre-injury) phase.

1. Prevent the creation of the hazard
(*e.g.*, safety features for all-terrain vehicles).

2. Reduce the amount of the hazard
(*e.g.*, speed limits).

3. Prevent the release of a hazard that already exists
(*e.g.*, no drinking and driving).

Secondary Prevention (injury) phase.

4. Modify the rate or spatial distribution of the hazard
(*e.g.*, child safety seats and safety belts).

5. Separate, in time or space, the hazard from that which is to be protected
(*e.g.*, pedestrian and bicycle paths separate from roads).

6. Separate the hazard from that which is to be protected by a material barrier
(*e.g.*, bicycle and motorcycle helmets).

7. Modify relevant basic qualities of the hazard
(*e.g.*, energy-absorbing materials on interior and exterior surfaces of motor vehicles).

8. Make what is to be protected more resistant to damage from the hazard
(e.g., strong fuel tanks).

Tertiary Prevention (post-injury) phase.

9. Begin to counter the damage already done by the hazard
(*e.g.*, well-situated, trained, and equipped emergency and acute care professionals).

10. Stabilize, repair, and rehabilitate the object of damage
(e.g., adequate medical equipment, devices, job and self-care training).

Injury Prevention strategies may include: the education of the population at large or of targeted groups to alter specific injury-related behaviors (education/behavior change); the passage and enforcement of new laws (legislation/enforcement); or changes in the design of products or of the physical environment (engineering/technology). When combined, the impact of each approach can be enhanced.

Perhaps the best example of an effective use of all three strategies is child passenger safety. Since 1978, every state has enacted a law requiring that children be restrained in federally approved child safety seats while riding in a motor vehicle. Safety seats which meet federal standards are known to be effective in reducing both injury and preventing death, when properly used. Education has been very effective in both passing laws requiring child safety seats and in teaching parents and caregivers how to use seats correctly. Combined, these efforts have been highly successful in reducing the number of deaths and injuries among children from automobile crashes.

Implementing injury prevention strategies requires the collaboration and support of a variety of professionals and public and private agencies. These can include fire and police departments, elderly services agencies, hospitals, emergency medical services, school nurses and teachers, health educators, children's services agencies, insurance companies, engineers, state head injury associations, and many others. Working together to implement the science of injury control, most injuries can be prevented.

Conclusion

"The tragic consequences of TBI are hard to describe and harder to understand, until you have experienced them. Sad to say, since my son's injury, our family has had plenty of experience that has led me to the conclusion that prevention of TBI is imperative!"

- Inta Hall, Public Policy Consultant, Massachusetts Head Injury Association, and parent of a TBI survivor

This report shows that Massachusetts has many people experiencing TBI and the lifelong consequences. Cause, demographic, and clinical patterns of TBI for Massachusetts residents are consistent with other studies in identifying high-risk groups, especially males 15-24, the elderly, and minority groups. Although motor vehicle crashes, firearms, and falls are highlighted in this report, other causes of TBI such as sports and recreation, occupational hazards, and violence not involving firearms also are factors. Interpersonal violence is becoming an increasingly significant cause of TBI.

Surveillance

A crucial part of the prevention and control of TBI is improved surveillance. Since January 1, 1994, the Massachusetts Rate Setting Commission has required acute care hospitals to include external cause of injury codes (E codes) in discharge abstracts, a step which will provide a more complete profile of TBI in Massachusetts. Rather than estimating the causes based on a few hospitals that already provide E codes, we will be able to determine the causes of almost all TBIs requiring hospitalization and relate them to the demographic, clinical, and fiscal information already being reported.

For TBI that does not warrant hospital admission, an additional data source exists. Computer software developed by the Department of Public Health is currently being used in selected Massachusetts emergency departments for recording all injury-related visits. (See chapter in this report on TBI Cases from One Emergency Department.)

Emergency, Acute, and Rehabilitation Services

Even with improved and increased preventive efforts, there will be new cases of TBI and the people injured will need a continuum of acute and long-term care and services.

The Office of Emergency Medical Services of the Department of Public Health has received a federal grant to improve the trauma care system in Massachusetts. In addition, the Department's Injury Prevention and Control Program has received a federal grant to improve the trauma care system for children. According to the Director of Pediatric Emergency Department Services at Boston City Hospital, "We need to develop more effective field triage guidelines to allow for the appropriate placement of children into hospitals which can meet the needs of traumatized children." These improvements will save lives and reduce the severity of disabilities from TBI.

"Although no state has developed a completely comprehensive continuum of care addressing all service needs for people with brain injury, several states, notably Massachusetts and Minnesota, have created statewide systems that provide quality care for people with brain injuries."(12) According to the Director of the Massachusetts Statewide Head Injury Program (SHIP), "Once injured, individuals with TBI are at high risk for secondary disabilities associated with the lack of timely, continuous and

appropriate rehabilitation and treatment, as well as substance abuse. Intense rehabilitation and post-acute interventions are necessary in order to maximize independence and facilitate community integration for TBI survivors." Adult TBI survivors referred to SHIP (approximately 30 per month) have generally exhausted all benefits, are Medicaid and/or SSI/SSDI recipients, are unemployed, and reside with their families. SHIP has received a federal grant to study the long-term consequences, services received, and outcomes for TBI survivors.

The Department of Public Health's Office of Disability Prevention addresses the prevention of secondary disabilities through its Access to Health Program funded by the U.S. Centers for Disease Control and Prevention. Through this program, health promotion and disease prevention activities are integrated into the operations of selected Independent Living Centers.

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Appendix

COGNITIVE CONSEQUENCES OF TBI

FUNCTIONAL DOMAIN	IMPAIRMENTS
ATTENTION/AROUSAL	Difficulty sustaining concentration or dividing attention.
	Distractibility and diminished capacity to resist interference from competing stimuli.
	Inattention or neglect (ignores stimuli typically on one side of space).
	Perseveration.
	Hypoarousal and persistent lethargy.
	Hyperactivity and impulsivity.
LANGUAGE	Word-finding or naming difficulty (anomia).
	Diminished verbal fluency.
	Difficulty with the expression and/or comprehension of language (traumatic aphasia).
	Difficulty with articulation of speech (dysarthria).
	Loss of the ability to communicate verbally.
	Impairment of language-related skills (e.g., reading, spelling).
MEMORY	Impaired ability re: acquisition of new information, verbal and/or non-verbal.
	Difficulty with retrieval of information.
	Persistent amnesia.
EXECUTIVE SKILL	Limited capacity for insight and reasoning.
	Impairment of problem-solving skills.
	Diminished capacity to develop and execute well-formulated plans.
	Cognitive inflexibility and limited capacity to generate alternative strategies.
	Impairment of organizational skills and ability to prioritize activities.
	Difficulty with initiating and/or sustaining purposeful activity.
	Diminished capacity for recognizing or anticipating the consequences of one's own behavior.
	Difficulty with regulating or modulating one's own behavior (disinhibition).

Source: LaVecchio F. Neurobehavioral Consequences of Traumatic Brain Injury: A Guide for Families. Boston, MA: Massachusetts Statewide Head Injury Program, 1992.

NEUROBEHAVIORAL CONSEQUENCES OF TBI

Personality change or intensification of pre-injury (premorbid) personality traits.

Emotional lability (i.e., verbal outbursts; abrupt mood shifts in the absence of clear precipitants; or exaggerated response to a known event/stimulus).

Impaired social skills (e.g., failure to acknowledge personal space, inappropriate familiarity, inappropriate laughter).

Denial or diminished capacity for acknowledging cognitive deficits or neurobehavioral symptoms, and their implications or impact on others. This is often associated with rationalization or projection of blame or responsibility for the inappropriate behavior itself onto others.

Egocentrism and diminished capacity to integrate feedback from others or appreciate someone else's perspective.

Paranoid thinking or misperception of a situation or intentions of others, at times associated with distorted recall of past events.

Denial of the need for, or diminished capacity to recognize, the benefits of recommended treatment/therapies.

Sexually inappropriate behavior (e.g., making inappropriate sexual comments or requests; exposing self; masturbating in a public place; sexually assaulting or molesting others).

Self-destructive or risk-taking behaviors.

Aggressive behavior towards others or property.

Source: LaVecchio F. Neurobehavioral Consequences of Traumatic Brain Injury: A Guide for Families. Boston, MA: Massachusetts Statewide Head Injury Program, 1992.

Summary of Methodology

A population-based methodology was developed to describe the incidence, causes, demographic, and clinical characteristics of new cases of traumatic brain injury (TBI) among Massachusetts residents. Fatal cases included deaths with any mentioned condition of TBI, regardless of underlying cause, annualized from the Department of Public Health's mortality files for 1989-91. Nonfatal hospitalized cases included acute care hospital discharges with any diagnosis of TBI, regardless of principal diagnosis, annualized from the Rate Setting Commission's Uniform Hospital Discharge Data Set for 1989-91. In the absence of statewide data for Massachusetts, nonhospitalized emergency department treated cases were estimated by applying rates per 100,000 residents by age/sex group generated from a Pennsylvania study that used a stratified random sample. For fatal and hospitalized TBI, ICD-9 diagnoses included concussions, skull fractures, and intracranial injuries without skull fractures. As recommended by CDC, open wound of head was also included for fatalities when no other TBI diagnosis was listed as a mentioned condition, resulting in a 42% increase in fatal cases. Cause by age/sex group was estimated from the group of hospitals with high levels of E-coding of TBI discharges. Lifetime costs of health care and lost earnings were estimated using national estimated costs per injured person by age/sex group adjusted for higher per capita personal health care expenditures and higher annual mean earnings in Massachusetts.

Incidence

Fatal TBI

Source of data: Massachusetts Department of Public Health Registry of Vital Records and Statistics mortality file, 1989-1991 annualized, which includes Massachusetts residents who died in-state or out-of-state, in or out of a hospital.

Case identification: any mentioned condition of traumatic brain injury regardless of underlying cause (i.e., a traumatic brain injury that is a condition leading to the underlying cause of death or contributing to but not resulting in the underlying cause).

Diagnoses* (ICD-9 codes):(1)

- concussion (850-850.9)
- skull fracture (800-801.9, 803-804.9)
- intracranial injury without skull fracture (851-854.1)
- other open wound of head (873)

From the literature: "Those using death certificates for head injury would be well advised to include ICD-9 code 873 ("other open wound to the head")."(15)*

* The distribution of first mentioned TBI was: intracranial injury (62.8%), open wound (30.0%), skull fracture (6.8%), concussion (0.4%).

From the literature: "Among people whose death certificates indicate that an injury was related to death, the injurious event is far less likely to be identified as the underlying cause of death for older people than for younger people. Thus, among the elderly, the role of injuries as a cause of death is substantially underestimated in tabulations based on the underlying cause of death in comparison with tabulations based on all mention of injury or injurious events on the death certificate... Not all external causes are equally subject to this apparent underrecognition as causes of death. In all age groups, motor vehicle and intentional injuries are identified as the underlying cause of death in more than 90 percent of the cases in which they are mentioned, whereas falls and other external causes are more likely to be mentioned but not selected as the underlying cause among the elderly."(5)**

Cause: percent distribution of external cause of injury (ICD-9 E codes) within age/sex groups based on underlying cause or mentioned condition of injury cause (when underlying cause is ICD-9 code below 800).

Exclusions: nonresidents, late effects (N905.0, N907.0, E929, E959, E969, E977, E989, E999), misadventures/complications of care (E870-E879).

Nonfatal Hospitalized TBI

Source of data: Massachusetts Rate Setting Commission Uniform Hospital Discharge Data Set, fiscal years 1989-1991 annualized, which includes discharges from nonfederal acute care hospitals in Massachusetts.

Case identification: any diagnosis of traumatic brain injury regardless of principal diagnosis (i.e., a traumatic brain injury established after study to be chiefly responsible for the admission of the patient to an acute care hospital for care or assigned as an associated diagnosis in conjunction with other injuries or medical conditions).

Diagnoses*** (ICD-9CM codes):(1)

- concussion (850.0-850.99)
- skull fracture (800-801.99, 803-804.99)
- intracranial injury without skull fracture (851-854.19)

From the literature: "The scope of brain injury may be underestimated because of current patient classification procedures in treatment facilities. The practice of recording diagnostic information for all persons discharged from acute care treatment facilities works well when single body parts or systems are injured. Because brain-injured patients typically have trauma to multiple body areas, however, often the recorded diagnoses become mixed and generalized to the point where persons with brain injuries cannot be readily identified. Precise and thorough recording of the full pattern of injuries is important. One can visualize the degree of difficulty, for example, with a patient who has a mild concussion and severe injuries to the chest. If the severe

* By including ICD code 873 for deaths with no other TBI mentioned condition, the total number of TBI deaths increased by 41.8%, almost all (95.6%) from firearms.

** Among deaths with any mentioned condition of TBI, the underlying cause was an injury (E800-999) for 96.0% of the cases; 99.7% for ages 0-44, 96.6% for ages 45-64, 87.8% for ages 65+.

*** The distribution of first recorded TBI diagnosis was: concussion (45.5%), intracranial injury (38.2%), skull fracture (16.4%).

injuries receive precedence in description and classification to the exclusion of the mild brain trauma, the need for rehabilitation services will be underestimated because the constellation of injuries is not accurately portrayed."(14)*

From the literature: "Historically, there have been no financial incentives involved in the classification of diseases. Now, the wide variation in the amount of reimbursement for different groups coupled with the existing variability and imprecision inherent in disease classification may result in systematic error, i.e., bias, in the categorizing and recording of diseases. It is not suggested that diagnosis-related groups per se will be used for epidemiologic research but rather that patterns of recording underlying diagnoses may change...Multiple diagnostic endpoints should be considered for future epidemiologic studies."(3)

Cause: percent distribution of external cause of injury (ICD-9 E codes) within age/sex groups for hospitals with 60%+ E-coding of discharges with traumatic brain injury was multiplied by incidence for all traumatic brain injury discharges by age/sex group. These 20 hospitals (see Table A-1), which are geographically dispersed across the state, represent 35% of TBI discharges and 85% of TBI E-coded discharges and have an E-coding rate of 84%. See Table A-2 for a comparison of cases from high (60-100%) and low (0-59%) E-coding hospitals.

Exclusions: nonresidents, residents hospitalized out-of-state, in-hospital deaths, transfers from other acute care hospitals, elective admissions, principal diagnosis or cause of injury of late effects (N905-909, E929, E959, E969, E977, E989, E999) or misadventures/complications of care (N958, N995-999, E870-E879), V codes, and deliveries (N630-676).

Estimated Nonhospitalized TBI

Source of data: stratified random sampling (based on volume of emergency department utilization, region of state, metropolitan/urban/rural location, trauma center status, and emergency care capabilities) of Pennsylvania emergency department logs and charts for 1988.(19) A demographic comparison of Massachusetts and Pennsylvania is included in Table A-3.

From the literature: "Few incidence studies have included non-fatal, non-hospitalized head injuries, despite the growing recognition that even minor head injuries can have disturbing behavioral and other sequelae."(19)

From the literature: "Data from the five National Health Interview Surveys for the years 1977-81 were pooled... Those hospitalized for head injury represent only 16 (11-22) percent of all head-injured people who were medically attended or experienced disability of at least one day and only 18 (12-25) percent of all medically attended head-injured people."(6)

Case identification: any emergency department visit within the sampling framework that involved a head injury-related loss of consciousness, impaired consciousness, concussion, possible concussion, skull fracture, or other indication of brain injury for which the patient was treated and released to home.(19)

* Among discharges with any diagnosis of TBI, the principal diagnosis was an injury (N800-999) for 93.8%; 96.7% for ages 0-44, 91.4% for ages 45-64, 84.3% for ages 65+. The principal diagnosis was TBI for 77.4%; 79.5% for ages 0-44, 73.5% for ages 45-64, 71.7% for ages 65+. The principal or first associated diagnosis was TBI for 90.2%: 91.1% for ages 0-44, 88.4% for ages 45-64, 88.1% for ages 65+.

Cause: Pennsylvania percent distribution of external cause of injury.(19)

Rates: Pennsylvania rates per 100,000 persons by age/sex group were multiplied by the Massachusetts census by age/sex group to calculate estimated incidence. Pennsylvania rates are subject to sampling error; the 5% confidence interval for the overall rate of 361 is 332.85-388.53.

Exclusions: nonresidents, old head injuries, return visits, admitted cases.

Clinical Groups for Fatal and Hospitalized TBI

Cases were divided into four groups based on first mentioned condition or principal diagnosis and associated conditions and diagnoses.

- Group 1. consists of cases with TBI as the only mentioned condition or diagnosis and no other types of injuries.
- Group 2. consists of cases of multiple injury with TBI as the first mentioned condition or principal diagnosis.
- Group 3. consists of cases of multiple injury with TBI as an associated condition or diagnosis.
- Group 4. consists of cases with multiple diagnoses with a medical condition as the underlying cause or principal diagnosis and TBI as an associated condition or diagnosis.

External Cause of Injury (E Code) Groupings for Fatal and Hospitalized TBI

- Motor vehicles: E810.0-E825.9, E958.5, E988.5.
- Falls: E880-E888, E957, E968.1, E987.
- Firearms: E922.0-E922.9, E955.0-E955.4, E965.0-E965.4, E970, E985.0-E985.4.
- Other: all other E codes.

Table A-1

Traumatic Brain Injury in Massachusetts, 1990 Hospitals with 60+% E-Coding of TBI Discharges, FY 1989-91			
Hospital	**City**	**Trauma Center**	**%E-Coding**
Bay State Medical Center	Springfield	Yes	64.1
Berkshire Medical Center	Pittsfield	Yes	92.1
Boston City	Boston	Yes	97.8
Cape Cod	Hyannis		92.3
Carney	Boston		72.3
Charleton Memorial	Fall River		84.6
Children's	Boston	Yes	89.6
Fairview	Great Barrington		83.3
Falmouth	Falmouth		79.2
Hillcrest	Pittsfield		77.8
Jordan	Plymouth		87.3
Lawrence General	Lawrence		78.1
Martha's Vineyard	Oak Bluffs		93.6
Mass. General	Boston	Yes	84.0
Milton	Milton		73.3
Morton	Taunton		94.7
Nantucket Cottage	Nantucket		66.7
Deaconess-Nashoba	Ayer		90.9
New England Medical Center	Boston	Yes	67.7
Noble	Westfield		70.2

Source: Massachusetts Rate Setting Commission, Uniform Hospital Discharge Data Set.

Table A-2

Traumatic Brain Injury in Massachusetts, 1990 Hospitalizations: High vs Low E-Coding Hospitals		
Variable	**High 60+%**	**Low 0-59%**
Age		
0-19	39.5	30.9
20-44	37.1	36.5
45-64	9.9	10.6
65+	13.4	22.1
All	100%	100%
Principal Diagnosis		
TBI	82.2	74.8
Other injury	13.1	18.1
Medical condition	4.7	7.0
All	100%	100%
Length of Stay		
1-4 days	62.5	64.8
5-14 days	23.5	24.1
15-28 days	7.9	6.7
29+ days	6.1	4.4
All	100%	100%
Clinical Group		
1: TBI only	38.3	32.1
2: TBI/other injuries	43.9	42.8
3: Other injuries/TBI	13.1	18.1
4: Medical condition/TBI	4.7	7.0
All	100%	100%
Disposition		
Home	82.7	79.7
Transfer	2.7	2.9
Skilled nursing facility	1.6	3.1
Intermediate care facility	0.9	1.5
Home care	3.3	5.3
Chronic/rehabilitation hospital	5.2	3.9
Psychiatric hospital	0.2	0.3
Other	3.4	3.3
All	100%	100%

Note: Percentages are annualized for 1989-91.
Source: Massachusetts Rate Setting Commission, Uniform Hospital Discharge Data Set.

Table A-3

Demographics for Massachusetts and Pennsylvania, 1990		
Variable	**Massachusetts**	**Pennsylvania**
Population*	6,016,000	11,882,000
% Urban*	84.3	68.9
% Metropolitan*	90.4	84.8
% Below Poverty Level*	10.7	11.0
Median Household Income*	$36,247	$29,005
Population Per Square Mile*	767.6	265.1
Race/Ethnicity:*		
% White	89.8	88.5
% Black	5.0	9.2
% Hispanic	4.8	2.0
Rape Rate**	34.0	26.0
Aggravated Assault Rate**	481.0	222.0
Injury Fatality Rates***		
Homicide	4.7	7.4
Suicide	8.1	11.2
Motor Vehicles	10.7	14.9
Falls	2.5	2.4

* Source: Statistical Abstracts of the United States.

** Source: Uniform Crime Reports, rates per 100,000 residents.

*** Source: National Center for Health Statistics, age-adjusted rates per 100,000 residents.

Cost Estimation

The cost estimation methodology for **Traumatic Brain Injury in Massachusetts** is adapted from the cost estimation methodology for **Head Injuries: Costs and Consequences**.(9) Estimates of cost for Massachusetts use the national costs per injured persons for 1985 inflated to 1990 and adjusted for higher costs in Massachusetts. Total national costs include cases with a principal diagnosis of TBI only and do not represent optimal care. See **Injuries in Massachusetts: An Overview of Causes and Costs** (13) for an explanation of the Massachusetts adjustment to national costs.

Fatal TBI

The 1985 national cost per fatally injured person by age/sex group was multiplied by the proportion of the national cost of health care (direct) per fatal injury (2.75%) over all ages*; the product was then inflated (1.977) to take into account the national increase in per capita personal health care expenditures from 1985 to 1990 and higher per capita personal health care expenditures in Massachusetts in 1990.

The 1985 national cost per fatally injured person by age/sex group was multiplied by the proportion of the national cost of lost earnings (mortality) per fatal injury (97.25%) over all ages; the product was then inflated by sex (female: 1.427, male: 1.330) to take into account the national increase in mean annual earnings from 1985 to 1990 and higher mean annual earnings in Massachusetts in 1990.

Hospitalized TBI

The 1985 national cost per hospitalized person by age/sex group was multiplied by the proportion of the national cost of health care (direct) per hospitalized injury (16.71%) over all ages*; the product was then inflated (1.977) to take into account the national increase in per capita personal health care expenditures from 1985 to 1990 and higher per capita personal health care expenditures in Massachusetts in 1990.

The 1985 national cost per hospitalized person by age/sex group was multiplied by the proportion of the national cost of lost earnings (morbidity) per hospitalized injury (83.28%) over all ages; the product was then inflated by sex (female: 1.427, male: 1.330) to take into account the national increase in mean annual earnings from 1985 to 1990 and higher mean annual earnings in Massachusetts in 1990.

Emergency Department Visits

The lifetime cost per person for health care for TBI in a study of medically related motor vehicle injury costs was inflated from 1985 to 1990 ($436*1.9777=$862) (10).

* The national per-person costs by age and sex (Table 3 (9)) combined estimates of both direct (health care) and indirect (lost earnings) costs. The percentages for direct and indirect costs were derived from total costs (Table 1 (9)) by class of injury and applied to per-person costs by age and sex.

Estimated Lifetime Cost of Health Care Per Injured Person

Definition: the value in 1990 dollars of lifetime medical and nonmedical expenditures for goods and services related to an injury (hospital stays for medical/surgical, psychiatric, and rehabilitative care, physician visits, prescription drugs, medical appliances, physical therapy, emergency transportation, attendant care, vocational rehabilitation, nursing home stays, insurance administration, home modification).

Exclusions: some insurance administration, attendant care for nonspinal cord injured people, care in institutional or intermediate care facility, legal fees.

Adjustment: The national cost per injured person in 1985 was inflated for Massachusetts using the percent increase in the national per capita personal health care expenditure from 1985 to 1990 (50.7%) and multiplied by the percent difference between the United States and Massachusetts in 1990 (31.2%), resulting in a total inflator of 1.977 (18). Because the 1990 per capita personal health care expenditure is not yet available for Massachusetts, an estimate was calculated by multiplying the 1989 per capita by the mean percentage increase between 1987 and 1989 (11.2%). See Table A-4.

Calculation: For each class of injury the adjusted cost per injured person for each age/sex group was multiplied by Massachusetts incidence.

Estimated Lifetime Cost of Lost Earnings Per Injured Person

Definition: the market value in 1990 dollars of goods and services not produced over a lifetime because of injury-related short-term or long-term illness or disability, or premature death (present value of lost future earnings or imputed housekeeping services).

Adjustment: The national cost per injured person by sex in 1985 was inflated for Massachusetts using the percent increase in the national mean annual earnings of persons from 1985 to 1990 (female: 29.3%, male: 22.0%) and multiplied by the percent difference in mean annual earnings between the United States and the Northeast region in 1990 (female: 10.3%, male: 9.0%), resulting in a total female inflator of 1.427 and a total male inflator of 1.330 (16,17). See Table A-5.

Calculation: For each class of injury the adjusted cost per injured person for each age/sex group was multiplied by Massachusetts incidence.

Table A-4

Adjustment to National Health Care Cost Per Injured Person Based on Per Capita Personal Health Care Expenditure	
1985:	
U.S. per capita	$1,496
1990:	
U.S. per capita	$2,255
U.S. inflator	1.507
Massachusetts per capita	$2,958
Massachusetts inflator	1.312
Total inflator	1.977
Source: U.S. Health Care Financing Administration.	

Table A-5

Adjustment to National Lost Earnings Per Injured Person Based on Annual Mean Earnings for Fulltime Workers by Sex		
	Female	**Male**
1985:		
U.S. mean	$18,088	$28,747
1990:		
U.S. mean	$23,392	$35,076
U.S. inflator	1.293	1.220
Northeast mean	$25,811	$38,231
Northeast inflator	1.103	1.090
Total inflator	1.427	1.330
Source: U.S. Bureau of the Census.		

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